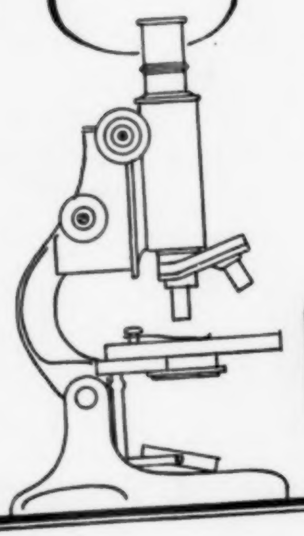
The SCIENCE COUNSELOR



A Quarterly Journal for
Teachers of Science in
the Catholic High Schools

VOLUME I
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SEPT., 1935

DUQUESNE
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PRESS

The Science Counselor

A QUARTERLY JOURNAL *of teaching methods and scientific information for teachers of science in the Catholic high schools. Published at Duquesne University, Pittsburgh, Pennsylvania, in March, June, September and December by*

THE DUQUESNE UNIVERSITY PRESS

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With the Editor . . .

September—Back to school. Back to the biggest and most important job in the world. Back to work with renewed enthusiasm, refreshed in body, in mind, and in spirit. Appreciative of the great privilege of being permitted to help shape the lives of the young, of aiding in the direction of their thinking and their doing. Determined that this year teaching shall be better planned, more purposeful, and more productive. Resolved to make a greater and more sustained effort to improve the teacher, in order to improve the teaching. Hoping to be a little more patient and tolerant, a little more understanding, and a little more helpful to the student than ever before. Both in the classroom and out of it. This reflects, we believe, the mood in which thousands of our teachers are returning to their tasks. For many of them, teaching is a life work. As teachers they realize and accept their responsibilities. They appreciate that it is the duty of every teacher in every Catholic school to see that the product of our schools shall be outstanding, "For every tree is known by its fruit."

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The Flora of Trinidad

• By L. J. Graf, C.S.Sp.
ST. MARY'S COLLEGE, PORT OF SPAIN, TRINIDAD

We are very happy to present this story of a tropical land that is far too little known by Americans. Father Graf, of the faculty of St. Mary's College, has taken full advantage of his unusually fine opportunities to study tropical plant life. His interesting account of the flora of Trinidad reveals his ability as a scientist and his enthusiasm for his work in the botanical field.

●

If you follow on the map the more or less crescent-shaped line of islands that stretches from the Yucatan Channel to the north eastern corner of the Venezuelan mainland, you will find at the extremity of the lower horn of the crescent the island of Trinidad. This island was discovered by Columbus on July 31st, 1498, the formation of certain mountain peaks on the southern coast suggesting itself to him as an emblem of the Trinity. The Carib Indians, who inhabited the island at the time, called their home Iëre, i.e., "The Land of The Humming Bird." The name was appropriate as well as beautiful, for even at the present day there may be counted as many as fifteen different species of these jewels of the bird world within the comparatively narrow limits of the island.

Trinidad is a distinctly tropical island, lying as it does ten degrees north of the equator and between the 61st and 62nd degrees west longitude. It is 60 miles in length and 54 in breadth, with an area of 1,754 square miles. Its temperature at midday varies between 88 and 92 degrees Fahrenheit; at night, during the cooler season of the year, in January and February, it may go down to 70 degrees. Its population, a very cosmopolitan one, is close on 400,000, the chief city, Port of Spain, counting over 80,000 souls.

Geologically, there is little doubt that Trinidad formed at one time part of the South American continent; its flora and fauna afford distinct proof of this; in fact, there is some evidence to show that a branch of the great Orinoco river, which still discharges its murky waters into the Gulf of Paria, flowed at one time along the base of the island's northern range of mountains and discharged itself on the eastern coast into the great Atlantic ocean. Trinidad is essentially an agricultural country, cacao, sugar cane, coconuts, coffee, tropical fruits such as oranges and other citric fruits, bananas, etc., forming its staple produce. The famous pitch lake, situated in the southern part of the island, is not only a curiosity for tourists and travellers, but also constitutes a regular and valuable source of revenue. Oil wells have been extensively developed within the last twenty years, and Trinidad ranks as the most prolific oil-producing area within the territory of the British Empire. It is a favoured resort for tourists, especially during the winter months; it has excellent roads, magnificent scenery, and high-class hotel accommodation.

After this preamble, we may now plunge straightway into the subject of the present article—the Flora of Trinidad. Trinidad has been called a botanists' paradise, and that not undeservedly. It ranks very high in Tropical America for the thoroughness of its botanical exploration. It possesses a first-rate Botanical Garden and a very complete herbarium, and the names of such collectors as Crueger, Grisebach, Lockhart, Purdie, Prestoe, Hart, and Broadway, figure in the herbarium collections of the famous Museums of the world. Gleason, in his survey "The progress of botanical exploration in tropical South America" rates Trinidad as one of twelve restricted regions which are considered adequately known. A new Flora of the island is in course of preparation, and a portion of it has already been published under the care of Mr. R. O. Williams, till recently Assistant Director of Agriculture in the island. Dr. N. L. Britton, of the New York Botanical Garden, has visited the island on several occasions in recent years for the purpose of completing the record of plant life in the South American continent.

The dominating forms of the Trinidad flora are, as might be expected, such distinctively tropical groups as palms, orchids, cactaceae, bamboos, bromelias, aroids, etc. Other characteristically tropical families represented by numerous species are the Malvaceae, Myrtaceae, Melastomaceae, Rubiaceae, Apocynaceae, Bignoniaceae, Verbenaceae, Euphorbiaceae, etc. The cosmopolitan families Compositae, Leguminosae, Gramineae are represented by a very large number of species. Conifers are practically absent, the only native species found being *Podocarpus coriaceus*. Cycads are conspicuous by their total absence, though forms introduced from the east thrive excellently under cultivation. The native ferns of Trinidad comprise a magnificent group, comprising nearly 300 different species, ranging from those interesting forms, the tree ferns, such as *Cyathea tenera* which grows to a height of 60 feet and species of *Alsophila*, to the pretty and diminutive "filmies" like *Hymenophyllum* and *Trichomanes*. Selaginellas and Lycopodiums abound in the higher regions particularly, where also are to be found what may be described as giant forms among the usually small mosses. Fungi, though well represented are not as showy as those of more temperate climes.

What strikes visitors from northern climates particularly is the profuse luxuriance of the vegetation, its varied character, and the magnificent display of ri-

otous colouring of the flowers, especially on the larger trees. Trinidad has a fairly well marked dry and wet season, but the number of deciduous plants is relatively small, whilst the tropical rain forests of the northern range experience practically no need for perennating mechanisms. Typical water plants are rare as might be expected in an area where rivers are scarce or torrential and lakes practically non-existent.

Total parasites are few; apart from the introduced *Cuscuta americana*, which is a pest to gardens and hedges, Trinidad can show only one or two forms—*Helosis guyanensis*, a root-parasite belonging to the Balanophoraceae, and *Cassytha americana* which resembles Cuscuta in general habit, but belongs to a different family, the Lauraceae. Semi-parasites are, on the other hand, very numerous, comprising a number of genera of the Loranthaceae. Total saprophytes among the flowering plants are represented by two species of *Voyria (trinitensis* and *uniflora)* and by *Dictyostega orobanchioides*, both to be met with growing at the foot of large forest trees, especially in the Mora forest, which, by the way, is the only gregarious form of forest to be found in Trinidad.

The island of Patos, which is the last of a chain of small islands that connect Trinidad with the mainland on the west, has a vegetation that is predominantly xerophytic, being practically overgrown by members of the family Cactaceae, most of which are to be found in a splendid collection gathered by the late Mr. W. E. Broadway by whose death Trinidad has lost its most valued and enthusiastic botanist, one who has given his name to many a species of the island's flora.

We may now mention briefly some of the island's most interesting plant associations. Pride of place must, of course, be given to the primeval rain forests, of which large stretches are maintained as Government Reserves, especially in the northern range. A visit to the island's highest peaks, Mt. El Tucuche (3072 ft.) or Mt. Aripo (3085 ft.), is always a treat for anyone interested in tropical vegetation. The huge giants of the forest, species of *Vitex, Carapa, Cedrela, Hymenaea, Hura, Ceiba, Eriodendron*, and a thousand others point their straight, high trunks, all branchless, into the sky like so many cathedral columns. Huge lianes or climbing plants, such as *Schnella, Swartzia*, etc. hang in mighty festoons from tree to tree. Epiphytes in countless numbers, *Philodendrons, Bromelias, Orchids*, ferns and mosses, cover the larger trees and make of each a very garden sufficiently extensive to keep a botanist occupied for days.

The ground floor has its own peculiar forms of shrubs, mosses, ferns, lichens, the only group not represented being the *Gramineae* which thrive only in clearings in the forest. To look down from some high peak over an expanse of tropical forest, especially at a season when trees like the *Poui* are in blossom, is an entrancing sight from which the visitor finds it hard to withdraw. True, the varied browns of autumn are generally wanting in a tropical forest, but this deficiency is richly compensated for by the rich variety of tinges of green so delicate as to defy description.

A plant association that is most interesting from the botanist's point of view is that of the so-called dry savannahs, of which the best-known is the Aripo Savannah which lies in the midst of the Mora forest lands that stretch along the base of the northern hills. Here we find an abundance of those strange insectivorous plants, the *Droseras* that entangle small insects with their glandular hairs and digest them to obtain the nitrogen that is lacking in the environment in which these plants live. There also we find at least four different species of *Utricularias* — bladderworts — which achieve the same object by entrapping tiny insects and other animals in little trap-like bladders. Rearing their blossoming heads over the lake of coarse grasses and sedges are to be seen some of the most beautiful of terrestrial orchids—*Cleistes rosea, Cyrtopodium cristatum, Epistephium parviflorum, Autostylis*, etc. A few stunted shrubs, such as *Byrsonima crassifolia* and *Chrysobalanus pellocarpus*, one or two feathery ferns, *Lycopodiums* and *Selaginellas*, one or two species of *Rubiaceae* and *Rosaceae* make up the limited but extremely interesting flora of such savannahs.

The sea-shore vegetation of a tropical island such as Trinidad has its own peculiar fascination. The long lines of curved cocoanut stems with their huge feathery fronds undulating in the ocean breeze frequently cover beds of plants that have found a way to grow and thrive right on the salty sand, where the waves break at high tide. *Ipomaea biloba* stretches its procumbent stems over the sandy wastes of the foreshore, anchoring itself by means of deep-seated roots, and unfolding its large funnel-shaped, pure-white corollas to our admiring gaze. The Sea-side Grape—*Coccoloba uvifera*—which in sheltered coves may reach 30 or 40 feet in height but, on rocky cliffs, forms a stunted, matted growth which at a distance looks like a well-clipped plot of turf, is endemic on the sandy beach. What astonishes visitors to the tropics most, however, is the fact that the vegetation even on rocky sea-side cliffs reaches down right to the water's edge. The long elegant leaf blades of *Pitcairnia integrifolia* with its bright red racemes of flowers, huge Adam's Needles *(Agaves* and *Aloes)* sending their great scapes with golden cones of blossoms high into the air, huge *Anthuriums* with leaves six feet long, spiny-leaved *Aechmeas* and *Bromelias (Bromelia chrysantha)*, ribbon-like trailing forms of cacti, especially the celebrated *Night-blowing Cereus* with its bright star-shaped perianth, great candle-like, thorn-covered tree-cacti side by side with the sphe e-shaped Turk's Head cactus, the beautiful Virgin Orchid *(Diacrium bicornutum)* clinging precariously in the crevices of the spray-splashed rocks, these and countless other forms of plant life rivet the nature lover's gaze and fill him with admiration for God's wonderful creation.

Let us finish with a short reference to another characteristically tropic plant association—the Mangrove swamp. Sombre and gloomy, evil-smelling and murky-watered though these swamps are, and not exactly the place where one would like to spend a holiday, they nevertheless possess an interest for the botanist all their own. The Trinidad mangrove swamps have a

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Copernicus

• By James J. Walsh, M.D., Ph.D. (Fordham), Sc.D. (Notre Dame)
EMINENT AUTHOR AND LECTURER, NEW YORK CITY

What is known about the man who first taught that the earth is not the center of the universe? What were the immediate and remote effects of the teaching of this priest, astronomer, physician and scholar?

Dr. Walsh, who writes of Copernicus and his work, is well known as the author of numerous books including Catholic Churchmen in Science, The Popes and Science, The Thirteenth Greatest of Centuries, and American Jesuits. His latest book is the Education of the Founding Fathers of the Republic.

It has been said that probably the greatest revolution in human thought that ever was worked came as the result of Copernicus' teaching that the earth was not the center of the universe with all the heavenly bodies going around it, but that on the contrary it was an extremely unimportant planet that went around the sun and was exceeded in size by a series of other planets or wandering bodies in the heavens. Man as the lord of the earth seemed up to this time to be the lord of the universe, but now he occupied a very different position except in so far as human nature had been dignified by the Incarnation.

No wonder it took several hundred years for people generally to grasp that pulling down of humanity from the pedestal on which man had so complacently set himself. And no wonder that for a time it seemed to contradict all previous thinking to such an extent that it appeared as though it must also contradict Scripture to a rather serious extent. The doctrine was presented very modestly, however, by a man who suggested quite humbly that it might be worth while considering this new way of looking at things, but who did not urge his novel ideas at all strenuously; and his book on the subject was not printed until after his death, though with full approval of the ecclesiastical authorities he had made a clear exposition and presentation of his teaching down in Italy during his student days some thirty years before.

The man who worked this revolution in human thought is surely worth while knowing as much about as we can glean from the unfortunately all too scanty records of his life that have been preserved for us. Copernicus is his name in Latin. He was the youngest of the four children of Niclas Copernigk who removed from Cracow in Poland to Thorn, now in East Prussia though then a city of Poland. Here the father of the future astronomer married Barbara Watzelrode, a daughter of one of the oldest and wealthiest families in the province. From this union our Copernicus was born in 1473. All the family, parents and children, were inscribed among the members of the Third Order of St. Dominic. It was one of these families in which religious vocations abound. Barbara, the eldest sister, entered the convent of Kulm of which her aunt Catherine was abbess. Many years later she herself became abbess by the choice of the community. Andrew, the eldest son, became a priest, and Nicholas, as canon of the cathedral of Frauenburg, assumed all the obligations of the ecclesiastical life though it is not sure that he received major orders. The usually accepted historical opinion is that he was a priest.

His collegiate education was obtained at the University of Cracow, the famous Jagellonian university founded by Casimir III, the great king of Poland, in the fourteenth century (1364). At the time Copernicus studied there it was one of the most important seats of learning in Europe. He devoted himself mainly to classical studies though it is said that his desire to read Ptolemy's astronomy in the original Greek tempted him to go down to Italy, where the Renaissance had revived the classical studies, for his graduate education.

While in Italy he wrote some Latin poems as a complement of his collegiate work, and he surrounded every mention of the Blessed Virgin and her qualities with poetic beauties. The poems when published were dedicated to the pope. The privilege of such dedication required special permission. He lived in a very scholarly time when cities were eager to found universities. No less than six universities, those of Ingolstadt, Treves, Tübingen, Mainz, Wittenberg, and Frankfort-on-the-Oder, were founded in the last quarter of the fifteenth century.

There are a number of astronomical references in Coernicus' poems but he seems to have had special attraction to all forms of science. It may be a little surprising that he took up the study of medicine, but Copernicus was following the advice of one of his teachers who knew his literary and scientific interests and knew also how little these contributed to the support of devotees, so he suggested that the astronomer poet should have some other profession. Coleridge several centuries later said a literary man should have some other occupation, to which Oliver Wendell Holmes added the well known tag, "and as far as possible confine himself to the other occupation." Copernicus' medical knowledge was much more than conventional, and he acquired no little reputation by his practical application of his medical science. One of his friends speaks of him as a "second Aesculapius."

Copernicus seems to have spent some ten years in Italy during which he broadened his classical education and developed his theory of the heavens according to

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A Science Teacher Answers

● By Sister Mary Lourdes, O.M.
VINCENTIAN INSTITUTE, ALBANY, N. Y.

This stimulating article is taken from a letter written in answer to some of the questions raised in our April "What do you think?" department. It was not originally intended for publication. The writer has consented to its printing, however, and we are sure that other teachers will enjoy and receive benefit from her sensible ideas and her crisp, business-like statements. This article contains valuable teaching hints.

Our schools need progressive and thoughtful teachers like Sister Mary Lourdes.

●

"Assignments are too long and too difficult."

This is not a new complaint. Sometimes pupils are justified in their protests. Often too much useless written work is assigned for home preparation. Instead of having the desired drill effect, such unnecessary work serves only to fatigue the mind so that it cannot assimilate the material that is essential.

When earnest students joke about their heavy assignments, or when the subject has lost its stimulating interest and becomes drudgery even to the best pupils (who may do all the required work only through fear of punishment), the teacher should make a *scientific examination of conscience.*

Are my assignments logical? Do I do my part of the work, or am I a lazy teacher?

Do I believe that the pupil will absorb information merely by doing the writing I require of him? Do I expect him to become a writing automaton? How long would it take me, an experienced chemist or biologist, to do the work I assign? Do I recall the amount of time I had to spend on assignments in my own college course? Did I ever consider the load too heavy?

Do I remember that my subject is not the only one that the pupil is carrying? I should. If I don't, the other teachers may suffer through my great and overweening desire for my class to carry off the highest honors, or because I do not want the humiliation of failure.

Am I putting the work over in such an interesting manner that the mentally gifted, those not so well equipped, and the mischievous, all are attentive? Am I condoning the laggard or inert pupil? He must be driven and pushed until it hurts.

All teachers realize that most of their work must be done in the classroom, not in the home. That is one of our big difficulties. Let me give an illustration. Suppose we are working percentage composition problems in chemistry. We can be sure that when the pupil has worked four or five problems correctly, he has grasped the principle involved. His interest has now been saturated. Why give him more of these problems as home work? The sixth, the tenth and the fifteenth problems are irksome. When we require needless repetition of this sort, we as teachers are the losers; for that which we sought, we found, and then lost again.

Our ideas regarding textbooks and their use and abuse may not meet with the approval of all teachers. Nevertheless with our methods we have achieved gratifying results. We often forget that high school pupils are immature. We are apt to take too much for granted. Place a textbook of general science, or biology, or even chemistry, in the hand of the average high school pupil. Ask him to read. Does he do it as if he had even a remote idea of the meaning of what he reads, or is he merely reading words? When a technical term appears on the page, has he any visual concept of it?

In my youthful days of teaching, I had the idea that pupils *would not* study; now I know that they *could not* study because they did not comprehend and did not know how to interpret what they read. Pupils must be taught how to study.

Do you, the teacher, lecture too much? Do your pupils tire of hearing you do all the talking? Our plan is to work with our books open on our desks. We read, discuss, illustrate on the blackboard, and study the diagrams in the book. Five or ten minutes are spent in supervised study. Books are then closed, and the pupils recite.

Let me illustrate again. Our new lesson in biology deals with relationships, including symbiosis and parasitism. We have already covered cross pollination and nitrogen-fixing bacteria. These topics we review briefly in our books and by recitation. We learn about fungi growth on trees and mistletoe growth on the oak. Now we apply our new terms. We analyze the words symbiosis and parasitism, spell them, write them, and define them. Our textbooks are consulted. We read the topic and emphasize the essential parts. Unfamiliar terms are always explained whether they are scientific words or merely new English words to be added to the student's vocabulary. Pictures illustrating symbiosis and parasitism are posted on the bulletin board.

The assignment for the next lesson is an oral report on the already explained examples of symbiosis and parasitism. In order to encourage the use of reference books, additional credit is given to the pupil who presents other examples than those found in the textbook. The pupils are sometimes asked to decide which recitations were good, and why.

Outlining the new lesson on the blackboard is another excellent method for bringing out essential topics and subtopics. Anatomy and physiology lends itself well to outlining.

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The Upper Carboniferous Flora

• **By A. C. Noé, Ph.D.** *(Chicago)*, **D.Sc.** *(Innsbruck)*.
ASSOCIATE PROFESSOR OF PALEOBOTANY, UNIVERSITY OF CHICAGO

What information have we concerning plant life on the earth millions of years ago? How has our information been obtained? Was the flora of that time similar to ours? Why do we know more about the trees of the period than about the herbs and shrubs? Dr. Noe, who is a Research Assistant at the Field Museum of Natural History, tells an interesting story.

Graham Hall, in the Field Museum of Natural History, Chicago, contains the reconstruction of a Coal Age forest as it might have grown somewhere along the shores of the great swamp which extended over Illinois, western Indiana, and western Kentucky some hundred million years ago. When these swamps, which covered most of present-day Illinois and parts of Indiana and Kentucky, were inundated by the sea, the rich vegetation which grew there was killed by sea water and covered by thick layers of mud and sand. But the land rose again above the sea level, and new land plants grew on the virgin soil. A swamp was formed which lasted until a new invasion of the sea covered it again with sand and mud.

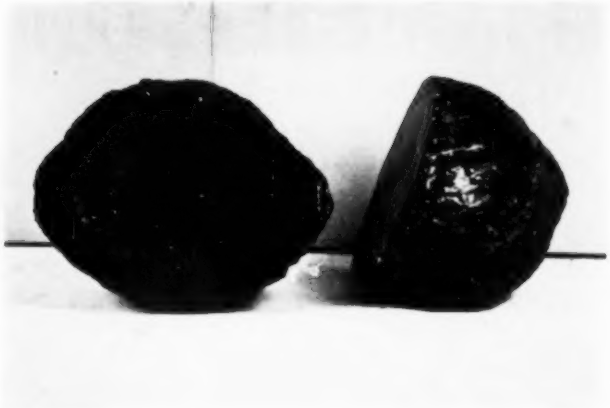
This process repeated itself in cycles, perhaps more than thirty times in the Illinois-Indiana-Kentucky basin, and a great many more times in other places. The buried vegetation turned into coal, and the overlying sand and mud became sandstone and shale. Between these sand and shale deposits can be found occasionally deposits of limestone which were produced from the fine shells which the floating marine fauna contained.

When we uncover the coal seams of our coal basins we find in the shale above the coal the impressions of leaves and stems and seeds of that bygone vegetation. Sometimes we can see limestone concretions in the coal which contain plant materials that have been saturated with a solution of calcium salts, mostly calcium carbonate; these lumps are called coal balls. (Fig. 2) They can be cut with diamond saws and ground down to microscopic thickness; or by a new method the limestone may be replaced by fine layers of cellulose, forming thin sections for microscopic investigations. These rock sections or cellulose preparations show the anatomic structure of the Coal Age plants often in the most marvelous preservation.

We have, therefore, two approaches to the flora of that time: one through the impressions, the outer surfaces of plant organs in the shale (Fig. 3); and the other through the coal ball, which reveals to us the inner structure of the plant.

On the basis of many thousands of fossils and microscopic preparations, the great reconstruction in the Field Museum was undertaken; and we are able to

• FIG. 1. *A view of the entire Coal Age forest*



• FIG. 2.

A coal ball from a mine in Southern Illinois. It has been cut in half; on the left the outside, and on the right the cut side of the ball are seen.

• FIG 3.

A nodule from Mazon Creek, near Morris, Illinois, showing the impressions of a leaf preserved in sandstone. On the left is the positive, and on the right the negative imprint.

visualize life as it appeared in those distant days when the great bituminous and anthracite coal seams of the Pennsylvanian series, as the period is called by geologists, were formed.

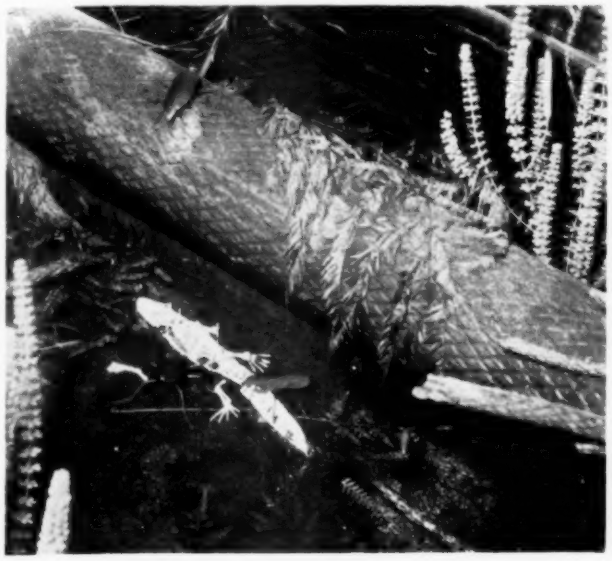
Let us examine this reconstruction. (Fig. 1). We see groups of trees, some shrubs, and an estuary connecting a great river with the sea. The landscape is that of a swamp near the ocean. It is a rich hydrophytic vegetation looking rather semi-tropical or tropical; and if one of us were some day transported into the orig-

• FIG. 4.

Part of a forest with an amphibian in the background.

• FIG. 5.

Close-up of a big dragon fly.



• FIG. 6.
Cockroaches eating the body of a little Salamander.

inal Coal Age swamp, we would not think that we were in a different climate or in an entirely different world, for the change would not be greater than if we were to fly suddenly in an airplane from a temperate North American landscape into a rain-forest on the shore of the Amazon River. We should see fern-like plants, palm-like stems, a comparatively small amount of shrubbery, no flowers whatsoever, and a rather meager fauna. The latter consisted, during Pennsylvanian times, of small amphibia (Fig. 4), of which the biggest was hardly more than three feet in length, enormous dragon-flies (Fig. 5) with a span of about thirty inches, little salamanders, insects of all sizes, mostly represented by cockroaches (Fig. 6), and a variety of flying types, but no butterflies, bees, nor true flies.

Let us look at some of the fern-like plants (Fig. 1). Some of them bore seeds at the ends of the branches, but had the leaves of true ferns; we call them seed-ferns, or Pteridosperms, because they seem to have been a link between the ferns and the seed plants. One of these seed-ferns resembled in appearance a modern tree fern. It has large seeds which have now been given the generic name Trigonocarpus, while the leaves of the fern are called Neuropteris. There is another seed fern type which was a climbing vine; its leaves had the generic name Sphenopteris, and its seeds that of Lagenostoma. Both types of seed ferns had also pollen-bearing organs. There were plenty of true ferns, mostly of the arborescent type. It seems strange to us that the leaves and stems of true ferns, and the leaves and seeds of seed ferns should go under different generic names; but they were found separately at first and the different organs were named before their connections in entire plant bodies were discovered.

In looking at the big stems which appear in the foreground of Fig. 1, we notice the peculiar ornamentation on their bark; some were covered with rhomboids which formed spirals and others with hexagons or round dots arranged in vertical rows. The former type appears under the generic name Lepidodendron and the latter under that of Sigillaria. Lepidodendron means "the scaly tree" because the bark looks like a fish or alligator skin. The name Sigillaria comes from the latin "sigillum" which meant the impression of a seal, such as our ancestors used to close their letters; and the ornaments on the bark appear like a row of seals. Both types of trees had long grass-like leaves which were attached in tufts at smaller branches, giving them the appearance of small green brushes, like shaving brushes. These trees bore large cones, similar

• FIG. 7.
Reconstruction of a young Cordaites tree.

to our present pine cones, which contained the spores. Lepidodendron and Sigillaria belong to the order Lycopodiales.

They soon became extinct during the Permian, which

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Epinephrine *The Drug That Brings the "Dead" to Life*

● **By Noel E. Foss, Ph.D.,** *(University of Maryland)*
INSTRUCTOR IN CHEMISTRY, DUQUESNE UNIVERSITY

This is a story about a medicine that is often mentioned in the newspapers but is little understood by the layman, Ep - i - neph' - rine.

Is it a new drug? Where does it come from? Can it be synthesized? How does it act? Can it restore the dead to life?

Dr. Foss's article will interest you.

●

Early in the summer of 1933 in Pasadena, California, the baby of H. Maynard Dickinson was rushed to a hospital with a severe case of lead poisoning. He had licked the paint off his new crib. A few minutes after arriving at the hospital the baby "died." Dr. John S. Hibben asked the parents if he might try one last method of restoring the baby's life. They gladly consented. In five minutes the doctor had prepared a hypodermic syringe containing one cubic centimeter of a crystal-clear solution—epinephrine! Carefully sterilizing with alcohol a small area over the heart, the doctor plunged the needle directly into the heart muscle of the baby and injected the epinephrine solution. A long tense moment followed. Slowly the little heart began again to function. Baby Dickinson was hurried to a respirator and in a short time the heart-beat was markedly stronger. For six days the infant was kept alive by repeated injections of epinephrine and the aid of the respirator, but the concentration of the lead absorbed had been too great and the baby succumbed to the effects of the poison.

Some time ago a German surgeon was performing an operation on the thoracic cavity of a woman. She apparently died from "collapse." So far gone was she that the heart failed to respond to massage through the open wound. Six minutes later a solution of epinephrine was injected into the heart. In ten seconds there was a slight rhythmic beat. Then the lungs began to function. One month later the woman walked out of the hospital a well person.

A case equally remarkable was reported several years ago by Dr. Carl Badon, attending physician to the American legation at Budapest. A man fifty-six years old, suffering from heart disease and apparently dying, was brought to him. He administered the usual remedies but with no success. The heart stopped beating, breathing ceased, and the man relaxed as though he were dead, a death-like pallor even appearing on his lips. Dr. Badon injected an epinephrine solution. In four seconds one could detect heart sounds with a stethoscope, breathing was soon resumed, and in two hours he was able to talk. Three months later he was discharged as cured.

Rarely a week passes that we do not read in the daily papers an account of the wonderful "life-restoring" properties of epinephrine. Epinephrine, sometimes called adrenaline, has been hailed as a raiser of the dead. So great and so wide-spread has been the publicity concerning this new drug that many people regard it as the famed "Philosopher's Stone" or "Elixir of Life" sought by the alchemists.

But the truth of the matter is that epinephrine is not nearly so new a remedy as people generally believe it to be. The Chinese discovered the medicinal value of epinephrine centuries ago. From the skin of the toad they obtained a poison which they called *ch'anser*. They used it for nose bleed, sinus trouble, and for pains of various sorts. This was none other than the epinephrine which physicians use today to check bleeding and to relieve asthma.

Natural Source

Pure epinephrine is a white crystalline powder, slightly soluble in water. Besides being found in the glands of certain toads, it is secreted by the adrenal glands of man and the higher vertebrates. It may be prepared synthetically. The adrenal bodies, or the suprarenal capsules as they are sometimes called in human anatomy, belong to the group of ductless glands. They were first discovered and named in 1563 by Eustachius, the famous anatomist who gave his name to the Eustachian tube of the ear. As early as 1849 the medical and physiological importance of the glands was recognized by Addison and considerable research was carried out on them. In 1856 it was shown repeatedly by Brown Sequard that removal of these bodies is followed by death.

The adrenal capsules are two small glandular organs lying like caps on the upper part of the kidney. In humans they are surrounded by strong-walled capsules. They are richly supplied with blood vessels, and in man they weigh together about six to seven grams. The adrenals are the first organs to be developed in the foetus. The gland is composed of two kinds of tissue, the cortex and the medulla. It is the medulla which secretes the epinephrine. In 1856 the great French chemist and physiologist, Vulpian, discovered in the medulla a "chromaffin" substance, so called because it became stained yellow when the gland was fixed in a solution of potassium dichromate and formaldehyde. It has since been shown that this chromaffin substance is identical with epinephrine. Since the adrenals are ductless glands, their secretion is discharged directly into the blood stream; hence they are organs of hidden outlets.

Nearly half a century elapsed after the discovery of the physiological importance of the glands before the chemical and pharmacological properties of the hormone were recognized. It was in 1895 that the ex-

traordinary rise in blood pressure caused by suprarenals was first observed by Oliver and Schaefer. About the same time the observation was made that the extract stopped the bleeding of small wounds. The immediate application of this discovery was the use of suprarenal extract as a hemostatic. A number of aqueous extracts were introduced by pharmaceutical houses.

The preparation of satisfactory extracts was extremely difficult because of the uncertainties connected with the extraction and because of the toxic substances that were sometimes obtained. Furthermore, such extracts could be evaluated only by pharmacological methods. It was soon evident that such preparations had but a limited value, and that the solution of the problem lay in the isolation of the hormone itself.

Isolation

In 1897 Abel and Crawford obtained an extract in an impure condition. Two years later Abel prepared the benzoyl derivative by means of the Schotten-Baumann reaction. The free hormone was called epinephrine by these investigators. In 1901 it was isolated by von Furth. He named it suprarenine. All three of these investigators had obtained a highly purified form of the extract but none was successful in obtaining the hormone in crystalline form. It remained for Takamine, that brilliant Japanese chemist and physiologist who spent most of his life in the United States, to obtain the first crystalline epinephrine. He gave it the name adrenaline.

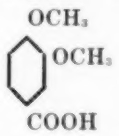
In the extraction process, the adrenal glands of oxen or sheep are properly disintegrated with water containing a little acetic or hydrochloric acid. The aqueous extract is concentrated. Alcohol is added to precipitate the protein, the solution is filtered, and the filtrate is concentrated in vacuum. Strong ammonia water is now added and in a few hours the impure adrenaline crystallizes. It is important to note that strong ammonia water is necessary for the first precipitation of crystals. Other workers before Takamine had added minimum amounts of weaker ammonia water and had obtained only an amorphous extract. It would appear from this that the hormone occurs in the suprarenal capsule in a form different from an ordinary salt.

About one hundred and twenty-five grams of epinephrine are obtained from one hundred and fifteen kilograms of the fresh tissue.

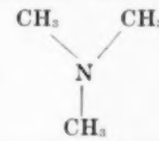
Chemical Structure and Synthesis

Aldrich obtained epinephrine in a crystalline state in 1901, and Abel in 1903. This accomplishment was followed by many attempts of chemists in every country to determine the composition and structural formula of the hormone. Takamine analyzed his crystals and proposed the formula $C_{10}H_{15}O_3N$. At first it seemed almost incredible that a hormone produced by the body could have such a small molecule. Shortly afterward, Aldrich isolated epinephrine crystals in a somewhat different manner and his analysis led him to propose the formula $C_9H_{13}O_3N$. Pauly confirmed this formula and it has since been proven to be correct.

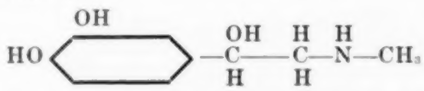
The credit for the elucidation of the structure is divided among several men. Due to the pink color produced by traces of oxidizing agents, the green color formed with ferric chloride, and the degradation product catechol, a catechol nucleus was suspected. Takamine had detected pyrocatechuic acid on fusion with potash. Von Furth, by treatment with concentrated acid, indicated the presence of the $—NHCH_3$ group. He also established the presence of the $—OCH_3$ group. Pauly in 1903 showed that adrenaline is optically active and must contain an asymmetric carbon atom. Jowett confirmed the work of his predecessors and also obtained more positive evidence by methylation and subsequent oxidation. By this means veratric acid



and trimethylamine



were isolated. This established the constitutional formula of epinephrine as:



There now remained only the synthesis of the base to establish its structure. In 1903 Stoltz, and in 1904 Dakin, each announced the synthesis of epinephrine. Stolz condensed catechol with chloracetyl chloride, reacted the chloracetyl catechol with methylamine, and reduced the adrenalone ketone to the adrenaline secondary alcohol.

The reduction of the ketone to the corresponding secondary alcohol presented great difficulties but it was successfully done both by electrolytic reduction and by the action of aluminum amalgam on the sparingly soluble ketonic base.

Several other methods have been announced for the synthesis of epinephrine.

The epinephrine resulting from the synthesis was, as was to be expected, a racemic mixture of optical enantiomorphs. Previous experience with other physiological stereoisomerides had shown that there was a quantitative difference in their action.

In 1908 Flacker resolved the racemic adrenaline into its optically active components. He formed the racemic bitartrate salt of adrenaline and extracted this with methyl alcohol. The *d*-adrenaline bitartrate dissolved and left the *l*-adrenaline bitartrate behind. On regeneration from the salt, *l*-adrenaline is obtained. The *d*-adrenaline may also be regenerated, racemized into its *d*-and *l*-variety, and the *l*-variety separated in the form of the bitartrate and finally regenerated again. Thus nearly all of *d*-variety may be converted to the *l*-adrenaline. The synthesis of natural adrenaline or *l*-methylaminoethanol catechol, its true chemical name, is therefore complete.

The resolution of the racemic form may also be accomplished by means of the organism, *Penicillum glaucum.* In this method the organism selectively consumes or destroys one optical antipode and leaves the other intact.

This marks the completion of the isolation and identi-

fication of the hormone of the medulla of the adrenal gland. The synthetic process has been worked out on a commercial scale and a manufactured epinephrine known as "suprarenine synthetic" is now available.

Small amounts of epinephrine have been isolated from the skin and glands of certain species of toads. Abel and Macht suggest that the toad secretes this poison when in danger of being attacked by some enemy. Usually the enemy recognizes the presence of the poisonous secretion. If the enemy persists in eating the toad, however, the enemy often dies from the poisonous effects.

Recently Chen, Chen and Jensen have disagreed with Abel and Macht and do not believe that the toad makes any practical use of his chemical armament. They think that the poisonous secretions of the toad are of no more use to him than are strychnine and brucine to the nux vomica plant.

Physiological Action

The isolation and synthesis of the hormone has enabled its physiological action to be worked out with certainty. Its typical action consists in a stimulation of the entire sympathetic nervous system. The effect upon any given organ, whether inhibitory, augmentory or indifferent, therefore corresponds to the action of its sympathetic innervation. It should be kept in mind that only when injected hypodermically does it produce any responses. When taken by mouth it is apparently destroyed in the stomach and has no effect.

Epinephrine produces a very powerful constriction of the blood vessels. This effect leads to three different applications. First, vasoconstriction is the main factor in the rise of blood pressure. Second, vasoconstriction aids in operations on the eye, nose and throat by decreasing the size of the small blood vessels. It thus promotes bloodless surgery. Solutions as dilute as one part in fifty thousand have been known to have a pronounced hemostatic effect. Third, its vasoconstriction prolongs anesthesia in a localized area when epinephrine is injected with a local anesthetic such as cocaine. By constricting the small blood vessels it prevents the rapid escape of the anesthetic into the blood stream.

In addition to its effect on the vascular system, epinephrine has a direct action on the heart. It stimulates the heart through the accelerator nerves which belong to the sympathetic system. So powerful is it, that one cubic centimeter of a solution containing one part of the drug in one thousand parts of water will cause a heart that has been removed from the body to clinch like a fist. It is in this field that epinephrine has achieved its most spectacular successes. It can stimulate a heart overcome by shock, or paralyzed because of its subnormal resistance to certain drugs. Such is the mechanism of its effect when used to resuscitate the heart of a patient suffering from surgical trauma, and it is the extraordinary cases of this type that are so frequently reported in newspapers. It is only in cases where the heart is overcome by some accidental shock, however, that epinephrine does have this remarkable property. It cannot renew a physical body poisoned by diseases such as cancer and tuberculosis.

The sympathetic nervous system also exercises the important function of regulating various metabolic processes. For example, a certain amount of glucose is normally present in the blood. Stimulation of the sympathetic nervous system causes the adrenal glands to discharge more epinephrine into the blood, which in turn increases the conversion of glycogen to glucose by the liver. Thus there may be hyperglycemia and eventually glycosuria, or the appearance of an abnormal amount of sugar in the urine.

Intravenous injections of epinephrine have been found to be of great value in asthma. There is a relaxation of the muscles of the bronchioles, thus dilating the air passages and facilitating the inhalation and exhalation of air.

Epinephrine is also a most effective treatment for acute anaphylaxis reactions. The intense itching and other uncomfortable symptoms which so often follow the injection of foreign protein serums, are temporarily relieved by this drug.

It is a great energizer, and emotional disturbances accentuate its production. When the body is threatened by any great danger, the brain sends impulses to the adrenal glands which in turn discharge their secretion into the blood stream, resulting in erection of the hair, relaxation of the bladder, dilation of the iris and all the symptoms which accompany fright or anger. As Sir Henry Dale has so ably stated, "It may be said to produce all the vascular and visceral reactions which accompany the emotions of danger, excitement and fright. The hair stands on end, the face becomes pale, the heart thumps urgently on the chest wall, and the arterial blood pressure rises rapidly, the muscular coats of the bronchioles relax and leave the airways clear for vigorous breathing, and glucose, the fuel of the muscular machine, is poured from the carbohydrate depot of the liver into the blood stream."

Epinephrine is truly a great remedy, but it is not to be believed that it is a "life saver" or a "cure all." There have been many cases reported where it has apparently performed miracles, but when it comes to the question of life, epinephrine is not a god. It is a medicine. It cannot restore life.

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X-rays and Their Applications

• By S. J. Broderick, Ph.D., *(New York University)*
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In this informative article Dr. Broderick discusses briefly how X-rays are produced and how they are used in medicine, in industry, and in scientific research.

You will be interested in this clear statement of modern ideas concerning the nature of crystalline matter, crystal analysis, and the application of X-ray spectroscopy to the study of metals.

What are X-rays? How are they produced? How are they used?

These questions are often asked. In our attempt to answer them we cannot go into great detail because of limited space. Nevertheless, we hope that our readers will become sufficiently interested to seek further information in some of the fine texts on this branch of science that are now available.

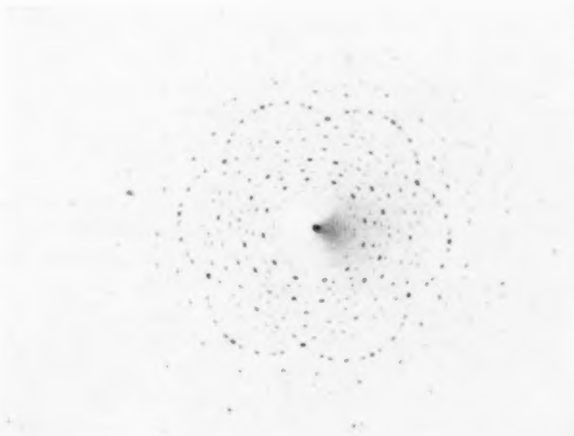
In 1895 Röntgen discovered the rays which bear his name and which more commonly are called X-rays. Almost immediately these rays found wide applicability in the field of medicine, and today X-ray therapy is indispensable in the treatment of many ailments. Not long ago X-ray tubes using voltages up to 220,000 were employed for this purpose; now there is an ever increasing demand for higher voltage tubes, reaching into millions of volts, for the treatment of cancer and other diseases. Recently, in Berlin, a 7,000,000 volt surge generator was built for use with a Lange-Brasch tube in cancer research and for physical experimentation.

In 1912 von Laue showed that X-rays could be diffracted by crystalline matter. This discovery opened up an entirely new field for research and for the commercial application of this most fascinating tool. As a result of von Laue's work it is possible to delve into the innermost secrets of crystalline matter, to see the spatial arrangements of the atoms and molecules in matter, and to learn something about the inter-atomic forces involved.

X-rays are similar to light rays in that both kinds of radiation move in straight lines; they pass through space without apparent intervention of matter; they affect a photographic plate; they excite fluorescence or phosphorescence in some substances; and they ionize gases. Röntgen and his contemporaries showed that X-rays differ from light rays in their inability to deflect from mirrors, prisms, and lenses; to obtain diffraction by gratings; or to obtain double refraction and polarization in crystals. Within the last few years, however, it has been demonstrated that X-rays may be totally reflected at very small glancing angles from mirrors, refracted in prisms, and diffracted by finely ruled parallel lines on glass or speculum metal.

Sodium light has a wave length of 0.589×10^{-4} cm., while that of the X-ray is about 10^{-8} cm. or 10^{-9} cm., that is about ten thousand times smaller than the wave length of sodium light. The short wave length of the X-ray is of the same order of magnitude as the distance between atoms in a molecule. This accounts for the ability of crystalline substances to diffract X-rays.

Diffraction or optical effects in one form or another are of common occurrence. The halo around the moon is simply the light from the moon being refracted by fog or moisture in the air as viewed by the observer on the earth. If one views a bright source of light through a finely woven material there will appear star rays or asterisms radiating from the bright point. Here the woven material acts as the diffracting medium. The play of color on mother of pearl and the colors of the peacock's feather and the butterfly's wing are examples of diffraction. For the production of these effects certain conditions must be satisfied, such as a regularity in the wave motion of light and a regularity in the diffracting material. The two regularities must be of approximately the same linear dimensions, that is, the even distances between single waves making up a light train of waves supply the first regularity, and these distances must be of the same order of magnitude as the size of the particles in the atmosphere through which the moon's rays pass. In the case of the color on the mother of pearl there is the rough regularity of the distances between striations, these distances corresponding in magnitude to those in the light wave train, thus causing optical diffraction and producing the color in the mother of pearl. On the peacock's feather and the wing of the butterfly, nature has dis-



• FIG. 1. *Laue Photograph of Beryl*

tributed a regular array of fine points which produce gorgeous unfading colors. When nature wants her colors to be lasting, she does not resort to dyes such as those upon which the color of flowers, plants and leaves depend.

Suppose now that a train of X-rays is substituted for the light waves, and for the diffracting medium a crystalline substance such as the mineral beryl ($3BeO.Al_2O_3 6SiO_2$) is used. As the short wave X-rays are not visible to the eye, no color effects are produced; furthermore, a photographic plate will be necessary to record the diffraction of the rays by the crystal. The plate will show a series of spots symmetrically arranged, proving that the atoms within the crystal of beryl are the diffracting medium and that they have a spatial arrangement according to a definite pattern. This is shown in Figure I.

X-ray Tubes

There are two general types of X-ray tubes, the electron type of which the Coolidge tube is a familiar example, and the so-called gas or ion tube in which the residual gas plays an important role. The principle of the electron tube is comparatively simple. Suppose one takes a piece of tungsten wire, makes a few coils in it by winding the central portion around a lead pencil and removes the pencil. This wire is now the X-ray filament. If about five amperes of current are passed through it, the wire becomes incandescent, giving off electrons, which are particles of electricity. Next suppose the filament is sealed into one end of a glass bulb and a round molybdenum rod about one-half inch in diameter, which will serve as the target or anti-cathode, is sealed into the other end. A high potential, in the neighborhood of 30,000 volts, applied to the circuit, (the target being one electrode and the filament the other), will produce a stream of electrons emanating from the filament and striking the target at a high velocity. The glass bulb is now evacuated to a pressure of 0.0005 mm. so that the high velocity electrons bombarding the metal target produce X-rays at the target, their nature or wave length being dependent upon the metal used as the anti-cathode. Such a tube is shown diagrammatically in Figure II. In this sketch is also shown the X-ray train leaving the molybdenum target, passing through the slit system to define the beam, diffracted by the powdered specimen and recorded on the photographic film in the quadrant cassette or camera. The kind of photograph obtained is a series of parallel lines such as is shown in Figure IV.

In the gas tube, the air molecules are split up into electrons and residual positive ions when the voltage is applied. The positive ions are hurled against the cathode thus setting free electrons which bombard the positive electrode or anti-cathode where the X-rays are produced. The gas tubes were the first to be developed for practical use but they are now far outnumbered by the electron type. Although the electron tube requires a higher vacuum for operation than the older type, it is easier to operate and gives a more constant source of rays.

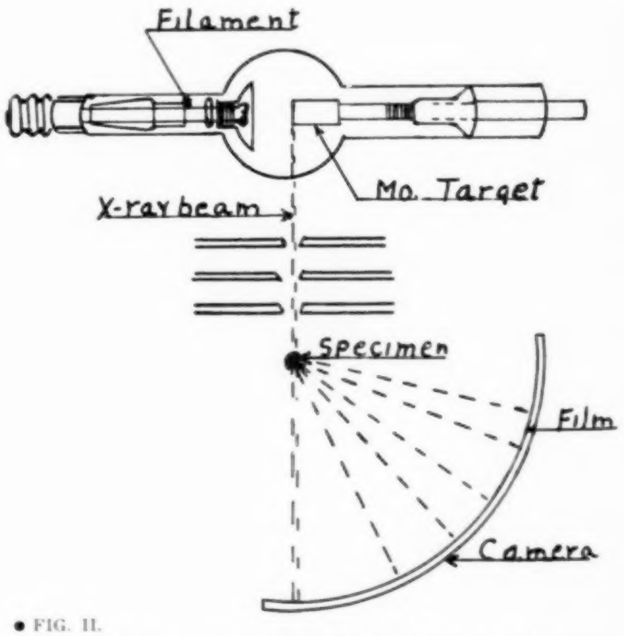
The application of X-rays may be conveniently divided into four groups:

1. The radiographic method for medical diagnosis.
2. The radiographic method for industrial diagnosis, applied especially to metals.
3. The use of X-rays for the study of the crystalline structure of metals.
4. The use of X-rays for the determination of chemical composition by X-ray spectroscopy.

Medical Diagnosis

The science of radiography is based on the fact that X-rays, because of their short wave length, are able to penetrate matter. They are differently absorbed by different substances; that is to say, all materials are not equally transparent to X-rays. Thus X-rays passing through the human body will be absorbed differently by the bone structures than by the flesh or the various organs. The experimental technique consists of passing a beam of X-rays through the object to be examined and, by means of a fluorescent screen or photographic plate, recording the varying intensities of the emergent beam, thus obtaining a shadow picture of the interior of the object.

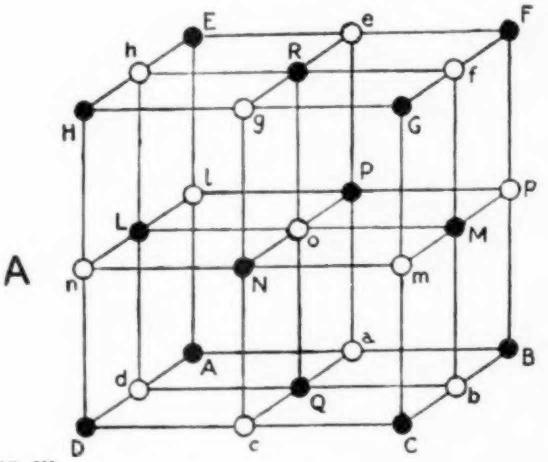
This most useful tool is indispensable to the medical profession. Every hospital is equipped with at least one X-ray machine, and small clinics and individual physicians find varied uses for it. Radiography has become most useful in the discovery and location of internal defects, in the examination of fractured bones preparatory to setting, and in studying the condition of the teeth as an aid to subsequent treatment. Locating bullets, swallowed pins and imbedded missiles is ordinary routine practice. Perhaps not so well known are the uses of X-rays in the diagnosis of tumors, of incipient tuberculosis of the lungs and joints, of dis-



• FIG. II.
Coolidge X-ray Tube and Quadrant Camera or Cassette

eases of alimentary tract, of stones in the kidneys and the gall bladder, and of diseases of the liver and pelvic organs.

Chemical methods used in conjunction with X-rays increase further the usefulness of this tool. For example, in the examination of the alimentary tract barium sulfate or bismuth salts mixed with food produce an opacity in the part to be examined, thereby revealing disorders such as focal points of infection, abnormal growths and mechanical bends or kinks. Similarly the injection of gases and iodized oil into affected parts enables these to be thrown in relief on the radiograph.



• FIG. III.

The unit cell of the sodium chloride arrangement of atoms. The positions of one kind of atoms are represented by black circles, of the other by circles.

Industrial Diagnosis

The radiographic method as used for industrial diagnosis deals with the gross structure of matter, particularly metal castings, and detects flaws, cavities and inhomogenities in solid objects. Such information is useful in controlling industrial processes, thus insuring a more uniform product. It has a practical utility in the safety of human life which is so often involved in the failure of metal or other objects. Industry considers it cheap insurance to X-ray practically all large castings in order to detect gas cavities caused by the liberation of gases from the metal or mold, sand and slag inclusions, pipes or shrinkage cavities, and cracks and porosity. In the construction of Boulder Dam it was necessary to build iron pipes thirty feet in diameter, the largest pipes ever made. Every inch of the welded seams of these pipes was X-rayed.

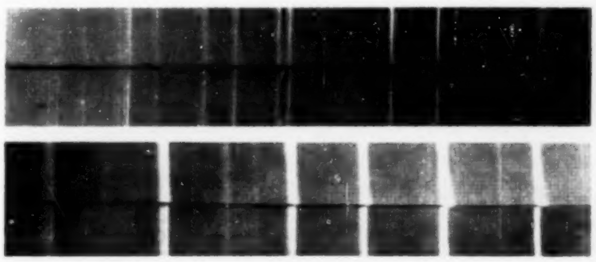
Crystalline Matter

Our knowledge of the nature of crystalline matter has been greatly increased by the use of the X-ray, for it is now possible to classify all metals and inorganic compounds according to their structures. Not only can the spatial arrangement of the atoms in a molecule be determined, but also the nature of the forces holding the atoms together. It is possible to measure accurately in Angstrom units the size of the unit cell making up the crystal. In the past much confusion has resulted from conflicting hypotheses regarding the nature of the crystallization of metals. Although these problems are still far from being solved, nevertheless, one is able to obtain a much clearer picture of the mechanism of solid solutions and of intermetallic compounds, and to appreciate why these compounds do not follow the laws which apply to inorganic compounds.

Crystalline materials are differentiated from amorphous substances in that the former have an orderly spatial arrangement of the atoms in the molecule; consequently, they will diffract X-rays. Amorphous bodies have no definite arrangement of the atoms and do not give a regular diffraction. Figure III shows the spatial arrangement of sodium and chlorine in the sodium chloride molecule.

Without attempting to go into the field of crystallography, we may state that all crystalline substances can be grouped into six systems: (1) Cubic system: crystals referable to three equal rectangular axes. (2) Tetragonal system: crystals referable to three rectangular axes, two of which are equal. (3) Orthorhombic system: crystals referable to three unequal rectangular axes. (4) Hexagonal system: crystals referable to three equal oblique axes, making equal angles with each other, and possessing one hexagonal axis. (5) Monoclinic system: crystals referable to three unequal axes, one of which is perpendicular to the other two. (6) Triclinic system: crystals referable to three unequal oblique axes.

There are four general methods for crystal analysis: Laue, Bragg, Rotation Photograph and the Powder Method. Although the interpretation of the results by each method requires a special procedure, they are all based upon the fundamental Bragg equation



• FIG. IV.

Powder diffraction patterns for alpha iron (body centered cubic), and platinum (face centered cubic).

$n\lambda = 2d \sin \theta$, in which

λ = the wave length of X-ray.

d = distance between atomic planes in the crystal.

θ = glancing angle that X-rays make with the surface of the crystal.

$n = 1, 2, 3$, etc. an integer.

when $n = 2$, the reflection at an angle θ is called reflection of the second order, and so on.

Continued on Page Eighteen

You Should Read

The Structure and Properties of Matter

● *By* HERMAN T. BRISCOE, Professor of Chemistry at Indiana University; New York; McGraw-Hill Book Company, 1935. x + 420 pp. 139 figs. $3.75.

Modern scientific theories are likely to undergo such frequent and extensive revision that it is difficult to keep abreast of the times. Our ideas of the structure of matter, for instance, are far different from those which obtained not so long ago when atoms and molecules were considered to be the ultimate divisions of matter. Today, a knowledge of sub-atomic structure is necessary to both the chemist and the physicist. Some of the new theories concerning matter are not easy to understand. They need careful explanation.

During very recent years the chemistry and physics of matter have been enormously enriched, but much of the material that has appeared in the literature has not heretofore been brought together, studied thoughtfully, assorted, and the best of it made available in compact and convenient form. The need for such a work is apparent. Dr. Briscoe has supplied it.

His book is an interpretation from the chemical point of view of some of the facts concerning matter that have been discovered, and some of the hypotheses that have been advanced, from the time of Aristotle to the period of Bohr and Schrödinger. It includes discussions of the earlier ideas of atomic structure, the periodic classification of the elements, radioactivity, valence, crystal structure, quantum mechanics, and the newest ideas of atomic structure. Numerous references to the literature are given.

Dr. Briscoe's book is not intended to be a critical review of all the work that has been done in the field. Neither is it a popular treatise. It is carefully written and should be helpful to all who are interested in a chemist's exposition of modern physical and mathematical concepts of matter. It will help the teacher keep up-to-date. It is not highly mathematical. Any person who has a knowledge of general chemistry and of elementary physics can read it with profit.

J. F. M.

From Galileo to Cosmic Rays

● *By* HARVEY BRACE LEMON; Chicago; The University of Chicago Press, 1934. 450 pp. $5.00 complete.

An unusual and interesting book. In a sense it is a "popularized" textbook of college physics which offers a new and attractive method of approach to the difficult subject matter of this science. It hardly needs other recommendation than that it was written by such a noted physicist and teacher as Dr. Lemon.

Mechanics, heat, electricity and matter, electricity and magnetism, and waves and radiation are discussed separately in a non-technical style, preparing the student for the more abstract aspects of the subject. The analogies employed are simple; the illustrations unique.

Although this book was originally intended as required reading to fit in with the Chicago plan of teaching so that students may be able to digest the subject matter of physics without going through the routine of a full year's course, it has been adopted as a textbook by other colleges.

Dr. Lemon's book is recommended as outside reading for students of college physics, especially for those who have difficulty in grasping the fundamentals of the subject. It is rich in ideas for presenting the subject in an understandable way, and for this reason it will be helpful to the physics teacher. Since it is written in a style that is not beyond the comprehension of the average high school science student, it will make a valuable reference book for the high school science library.

R. S.

The Teaching of Biology

● *By* WILLIAM E. COLE, Ph.D., Associate Professor of Science Education in the University of Tennessee; New York; D. Appleton-Century Company, Inc., 1934. xiv + 252 pp. $2.00.

This book is a stimulating and practical "how to teach" book. Every teacher of biology can be benefited by it. The April, 1935, number of the *Journal of the National Education Association* lists it among the sixty important books in education published in 1934 that will be of great benefit to teachers.

Dr. Cole's book is designed not only to aid teachers on the job, but also for use in professionalized education courses, and by prospective biology teachers in training. It will be helpful to teachers and students of all these groups.

The author gives a brief account of the history of science teaching in secondary schools, discusses the present status of biology in the high school, and outlines the general and working objectives of this science. Then he considers the selection, organization, and articulation of subject matter; laboratory and classroom teaching methods; instructional aids; individual differences; tests and measurements; and the training and professional growth and advancement of the biology teacher. He discusses such points as lesson planning, drill, motivation, and ways of obtaining teaching material. Copious references to the literature are included.

Dr. Cole would have teachers emphasize the cultural and functional aspects of biology. He prefers to have this subject taught as a single unified course, rather than as the two independent units of botany and zoology.

H. C. M.

X-rays and Their Applications

Continued from Page Fifteen

Crystal Analysis

Laue's method of showing the diffraction of X-rays by a crystal requires that the rays be heterogeneous, that is of all wave lengths, such as are emitted by a tungsten anti-cathode when bombarded by electrons having velocities due to 70,000 volts. The wave lengths vary from 0.18 to 1.00 Angstrom units. During the exposure the crystal is at rest. In the fundamental equation $n\lambda = 2d \sin \theta$, the flexibility is supplied by the variability of λ, the other values being constant. The kind of photograph obtained is shown in Figure I, a series of dots of varying intensities arranged in a symmetrical pattern. The interpretation of these patterns is rather difficult. Their chief utility is in determining the symmetry of crystals, and grain size and distortions and strains in crystallized metals.

Bragg's method is by far the easiest whenever simple crystals are available. The crystal is mounted upon a rotating table, the orientation of which is measured by scale and vernier. The X-rays which must be monochromatic (of single wave lengths) are reflected from the crystal and received in an ionization chamber filled with a gas which responds readily to the action of the rays. For example, if the target of the X-ray bulb is of molybdenum or rhodium, it is convenient to fill the chamber with methyl bromide vapor, because the characteristic rays of either of these metals are strongly absorbed by bromine and produce correspondingly strong ionization. The intensity of ionization is measured by an electroscope.

The Rotation Photograph method is also useful. A horizontal pencil of monochromatic rays is made to impinge on a crystal which revolves about a vertical axis. The pencil is limited by a fine cylindrical film, the axis of the cylinder coinciding with the axis of rotation. As the crystal revolves, one set of planes after another is brought to an angle with the incident rays such that $2d \sin \theta$ is fulfilled and reflection takes place. An impression is made on the plate by the reflected ray. The developed plate shows a collection of spots due to the various planes that have passed through favorable positions. The spots lie on ordered lines. All these methods, however, are unsuitable except for reasonably large crystals, free from uncertainties due to imperfections and twinning of crystals. Consequently their use is greatly restricted.

The Powder Method has by far the widest applicability. As in the Bragg method, monochromatic radiation is used, but instead of confining itself to perfect crystals, it uses a powder, fine enough to pass a "200 mesh" bolting cloth. Such a powder requires no rotation since every atomic plane is present in every possible orientation; so there must be some individuals from each set of planes which are oriented at the correct angle to diffract the X-ray beam. If the volume of powder is large enough and sufficiently fine, for any set of planes there will be enough particles oriented so that the combined effect will be similar to that from a single large crystal. The powder is placed in a cylindrical glass container of about 0.6 mm. inside diameter and 40 mm. long. Since every atomic plane in the powder has some representatives at the correct angle for diffraction, the whole diffraction pattern is photographed simultaneously.

There are many modifications of the powder method in use. The foregoing description applies to the General Electric Diffraction Apparatus. The type of photogram obtained by this method is a series of parallel lines, the lines varying in intensity and distance from each other as shown in Figure IV. The upper photogram is that of alpha iron (body centered cubic), and the lower of platinum (face centered cubic).

The interpretation of these photograms is a somewhat tedious task. By means of the equation $n\lambda = 2d \sin \theta$ and the radius of the camera it is possible to calculate the interplaner distances d. Once the interplaner distances are known it is possible in the case of the simpler systems, to find, by a systematic cut and try method, an arrangement of atoms in space which will account for the observed interplaner distances.

Chemical Composition

The application of X-ray spectroscopy to the study of metals is concerned with the determination of the chemical composition of metals and alloys. Either the emission or the absorption method may be used to give a qualitative or, under proper conditions, a quantitative analysis of the material examined. In the emission method, the sample is made the target of an X-ray tube, and the wave lengths of the characteristic radiations which it emits are measured by the usual methods of X-ray spectroscopy. A comparison of these wave lengths with those characteristic of the different chemical elements furnishes a qualitative chemical analysis of the sample; a comparison of the intensities of the lines provides a basis for a quantitative estimate of their relative amounts.

In the absorption method, the sample is placed in a beam of X-rays from a tube that is emitting a continuous spectrum. The X-rays that have passed through the sample are analyzed spectroscopically and the wave lengths of the critical absorption edges of the elements present in the sample are measured. These serve for a qualitative analysis of the sample, while a measurement of the intensity of the continuous radiation for wave lengths just above and below the critical absorption edge for any element furnishes the data required to compute the mass of that element present in the path of the X-ray beam.

Of the various applications of X-rays, that applying to X-ray spectroscopy is the least used. It requires a special technical skill for its manipulation. Its greatest usefulness is in highly scientific problems. A noteworthy achievement of this method is the outstanding work, in 1923, of Georg von Hevesy and Coster in the discovery and identification of the element hafnium.

Have You Read?

Worth while articles in the current literature of science. (You may find these magazines at your public library.)

A CONTRACT METHOD IN HIGH SCHOOL CHEMISTRY, by M. P. Schultz, Senior High School, University City, Mo., in *The Journal of Chemical Education*, May, 1935.

Students are permitted to advance as fast as their capacity and application warrant.

THE DEVELOPMENT OF CHEMICAL SYMBOLS, by Ingo W. D. Hackh, College of Physicians and Surgeons, San Francisco, in *The Scientific Monthly*, March, 1935.

The use and development of chemical symbols is traced through its various stages from the Egyptian hieroglyphs to the most modern notations. An interesting article.

WHAT SHALL WE TEACH IN CHEMISTRY? by G. M. Bradbury, Lakewood High School, Cleveland, Ohio, in *School Science and Mathematics*, April, 1935.

Objectives in science instruction. The principles of learning which the teacher must consider. Thought-provoking.

THE DISCOVERY OF BETTER TEACHING TECHNIQUES FOR GENERAL SCIENCE, by Truman D. Fox, J. Sterling Morton High School, Cicero, Ill., in *Science Education*, February, 1935.

A study concerned with determining pupil errors in a general science course, examining the most common ones, and formulating teaching techniques that should reduce such errors.

GREGOR JOHANN MENDEL, by D. J. Harbou, Sindal, Denmark, in *The Scientific Monthly*, April, 1935.

An interesting biographical sketch, adapted for publication by Dr. Edwin R. Helwig of the University of Pennsylvania.

SHELTERBELTS—FUTILE DREAM OR WORKABLE PLAN? by Raphael Zon, Director of the Lake States Forest Experiment Station, in *Science*, April 26, 1935.

A discussion of the President's idea of belts of forest trees stretching from the Dakotas to Texas. The exaggeration and misinterpretation to which the plan has been subjected.

EFFECTIVENESS OF THE INDIVIDUAL LABORATORY METHOD IN SCIENCE COURSES, by Thomas Morse Barger, Illinois State Normal University, Normal, Ill., in *The Journal of Chemical Education*, May, 1935.

A questioning of the aims and methods of science teaching which originally led to the adoption of and continued use of the individual laboratory method.

FILTRATION, by Edwin Letts Oliver, President, Oliver United Filters, Inc., San Francisco, Cal., in *Chemical and Metallurgical Engineering*, April, 1935.

The development of filtration from the crude methods of the ancients to the highly efficient processes of the present day.

REFINING THE SALT OF THE EARTH, by James A. Lee, Managing Editor, in *Chemical and Metallurgical Engineering*, March, 1935.

Modern methods of purifying sodium chloride.

ACIDS, BASES, AND SALTS, by Martin Kilpatrick, University of Pennsylvania, in *The Journal of Chemical Education*, March, 1935.

Modern ideas of acids, bases and salts which may surprise and interest you.

TURNING BACK TIME, by Emily C. Davis, in *Science News Letter*, April 13, 1935.

What archaeologists have discovered about life in Mesopotamia, 3000 B.C.

Upper Carboniferous Flora

Continued from Page Nine

followed the Pennsylvanian, or Coal Age. The Lycopods which survived are now herbaceous; they are the poor relatives of the once great and mighty trees which filled the swamp-forests in the Coal Age.

Looking again at Fig. 1, we see on the right side some jointed stems with whorls of branches which in turn bear whorls of leaflets. These trees are called Calamites, and they belong to the order Equisitales. Here again the poor relatives remain; the great, magnificent Calamites soon became extinct and Equisitum, our common scouring rush, has survived.

The types of plants which have been discussed up to now are either true ferns and fern allies, or are like the Pteridosperms, or seed ferns, a connecting link between the ferns and the modern Cycads. But there were also true Gymnosperms at that time, forerunners of our modern conifers. In Fig. 7 we see the reconstruction of a small specimen of Cordaites. Adult plants of this genus probably reached a height of one hundred feet; they did not have small needles but broad, long leaves with a heavy texture, somewhat like the conifers of our time, but immensely larger.

It seems strange that we know so much more about the tree ferns of the past vegetation than of the herbs and shrubs, and it is quite possible that plant life was mostly represented by trees in those earlier ages and that the herbs and shrubs are to a large extent a reduction form.

Even as late as the Tertiary the trees predominate. Perhaps the leaves from trees were more easily preserved than herbaceous forms because leaves could fall off or be broken off by the wind and rain and thus have a chance to become embedded in mud or sand. When the mud became shale, or the sand sandstone, the leaves became fossils. Grasses and other herbaceous types decayed on the spot. This may be one reason that we have comparatively few herbaceous plants throughout geological time. Nevertheless, we must admit that there were shrubs and herbs because a few have been found, even in the Coal Age. The most characteristic was probably a plant which grew in large tufts like the so-called modern bed-straw, or Galium. It can be seen in Fig. 1 growing in front of the big fallen tree, and it belongs to the extinct genus Sphenophyllum.

The plants of the Upper Carboniferous, or, as it is commonly called in this country, the Pennsylvanian period, grew many millions of years before our time. Their difference from our plants was not in essentials, because they breathed and nourished themselves and propagated very much as the plants of our time. Most likely their organs were brown, green, yellow, or reddish; since they had no flowers, the brighter colors probably were absent. The Pteridophytes and Gymnosperms were well represented, but the Angiosperms

did not exist as yet. We know very little about the Bryophytes of that time, but probably they were meagerly represented. Thallophytes, of course, existed in abundance both in the water and on land.

Progress in the plant kingdom is slow; but, as everywhere in the world of organisms, it shows itself as an innate struggle of the organic creation to reach a higher level of development. This urge for rising above one's level, which God has bestowed upon man, animals, and plants, and perhaps also upon the stars and the entire universe, is what we may call the spirit of evolution.

The Flora of Trinidad

Continued from Page Four

very limited range of vegetation, as, for that matter, they have wherever they are found. Four genera of mangroves — *Rhizophora, Avicennia, Conocarpus* and *Laguncularia* make up the *piece-de-resistance* of these areas which with their salty or brackisk waters seem so ill-adapted for plant-life. Yet the mangroves seem to thrive exceedingly under these ill-favoured conditions. Their sombre-hued, glossy, crystal-covered foliage never fails them. The almost impenetrable tangle of stilt-roots of the *Rizophora* kind, the finger-shaped breathing roots of *Avicennia* which defy all the rules of geotropic tendencies, the viviparous seeds of *Rhizophora* with their pointed radicles six inches long or more which enable the young plants to fix themselves in the muddy soil, are all so many successful adaptations to a difficult habitat which have enabled the mangrove tribe to survive in the struggle for existence by occupying a vacant space in nature's economic system. Here and there you will find patches of the white-flowered *Dodeca maritimum*, of the malvaceous *Malache scabra*, of the long-fronded fern, *Acrostichum aureum*, so-called because its sori give the tips of the leaves a golden gleam, rows of spiny *Bactris* palms, some *Portulaccas*, and giant sedges complete the limited vegetation of the mangrove swamp.

Such are some of the "high lights" of Trinidad's floral wealth. We hope this article may be of interest to the readers of "The Science Counselor." Should any of its readers have an opportunity of undertaking a journey to the Caribbean and its sun-lit isles, we would invite them to come and see for themselves whether the above description is true to nature or whether it is to be taken *cum grano salis* as the effervescent outpouring of a well-meaning but over-enthusiastic lover of tropical plant-life.

"A Catholic can be a good dogmatist in religion and a good skeptic in science."—*Nicholas Dietz, Jr.*

What Do *You* Think?

For discussion in your faculty group

A discouraged teacher makes the following complaint: "My senior students in chemistry have difficulty with the problems based on molecular weights. They make stupid mistakes even in the calculation of the weights. They cannot state proportions correctly. They are not able to solve a proportion once it has been stated. The work in arithmetic in our schools must be very poor. What shall I do?"

◆

A bright pupil is talking to his teacher of biology. "My father says that the things you are teaching us about heredity are not so. Can you lend him a book to prove you are right, for he says not to believe the things you tell us." The book was returned by the boy the next day with this comment: "Dad still thinks this is bunk." How can I convince this boy, as well as others in similar cases, of well known fundamental scientific truths?

◆

"My pupils regard illustrations merely as entertainment, as things to be looked at. They have no idea of the value of charts, graphs, and diagrams." This is the lament of Sister Mary Gertrude who teaches general science.

◆

A teacher has a student of keen intelligence who works daily for 100%. She asks rather frequently for individual assistance in order to maintain her record. In the same class are three students with averages of 50%, 60% and 70%. Who should be helped first, if the teacher knows she has time to assist only two of the four? One pupil was absent the preceding day. Would this affect the teacher's decision?

◆

Sister Mary Agatha is concerned because the pupils in her class in chemistry make many errors in oral English. She is continually correcting them, but her corrections have little effect. The pupils seem to be incurably careless.

◆

"In grading my pupils how much weight should I give to laboratory work in biology?" asks Sister Mary Genevieve. "Some of my pupils do excellent class work. They are good in their examinations, but they are failures in the laboratory. Others, intensely interested in the mechanical details of handling and studying specimens, are failures in theory."

Copernicus

Continued from Page Five

which the earth was not, but the sun was, the center of our solar system and instead of the sun going around the earth, as it seemed to do, the earth went around the sun. The book in which he outlined that hypothesis, *De revolutionibus orbium celestium* (On the Revolutions of the Heavenly Orbs), was, as has been said, not published until after his death. It is sometimes said that the reason for this delay in publication was because Copernicus feared a storm of religious persecution. The book was dedicated, presumably with permission, as was the custom, to Pope Paul III, the reigning pontiff, who was one of the great reforming popes of that period. There was not the slightest hint of anything unorthodox in his theory so long as it was looked upon as a theory. At that time all the astronomers of Europe were agreed in the acceptance of the Ptolemaic theory according to which the sun went around the earth. This continued to be the teaching of all of the astronomers until after Galileo's time, and it must not be forgotten that the reasons put forward by Galileo for the acceptance of the Copernican theory have all been brushed aside and the Copernican theory is now accepted for very different reasons from those advanced by either Copernicus himself or Galileo. By a fortunate chance Copernicus hit upon the right theory of the universe and Galileo followed him, but their reasons for their teaching were not convincing.

It was nearly a century after the publication before the Copernican theory began to attract any widespread attention. It would seem that a generation which thus neglected its greatest scientific genius must surely be lacking in acuity of intelligence, for here was a great truth which has revolutionized human thought, and yet no one recognized its importance at all until several generations had elapsed.

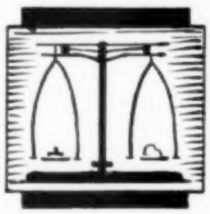
It must not be forgotten, however, that exactly the same sort of thing happened in our supposedly very brilliant scientific nineteenth century. Father Mendel, the Augustinian monk, working in his monastery garden, elaborated certain laws of heredity which have revolutionized biological thought in the twentieth century. Father Mendel's discoveries remained absolutely unrecognized for a long generation until the beginning of the twentieth century. They were published where all the world might read them, but the significance of them was utterly missed. Father Mendel was perfectly sure that a time would come when men would recognize the value of his work but though he published it where it was easy to get at, he was many years dead before the scientific world appreciated what a marvelous bit of experiment and observation he had accomplished.

Copernicus is one of the most original geniuses of all times. He obtained the leisure which enabled him to accomplish his great work as one of the canons of the cathedral of Frauenberg where his daily duties would leave him many hours for study and writing. His medical profession, which was never exercised for gain, enabled him to be a consultant when his friends

among the clergy particularly suffered from severe ailments of any kind. He is a type of the eve of the Reformation period, scholar, astronomer, physician, and clergyman. He seems to have had an extremely happy life. Happy people have no history and that is why it is hard to be sure of details of his career, and why it has been easy for some to distort the significance of his life. At his own request they engraved upon his tombstone the prayer:

"I ask not the grace accorded to Paul nor that given to Peter; give me only the favor Thou didst show to the thief on the cross."

There is perhaps no better example in all history of the simplicity of true genius and no better example of how sublimely religious was the soul that far transcended the bounds of the scientific knowledge of its own day.



Another Teacher Answers

"I, too, have encountered the many difficulties that are often experienced when pupils do not use a textbook properly. To a considerable extent I have been able to overcome them by the use of the following methods:

First: I have the class read the assigned material silently, one paragraph at a time. Then I call on any pupil to give the contents of the paragraph in one short sentence. Sometimes I even limit them to a definite number of words. In that case it is assigned as written home work. Second: I give them suggestive study questions—at least one for each paragraph. Third: Occasionally I assign them the work of making out a number of questions—ten or fifteen to an assignment.

I use one or other of these methods during the entire first semester. Later, I use only the third type. It is the most difficult of all, but if the pupils succeed in making up good questions I have exceedingly little explanation to make on the textbook material. This gives me more time for better work. Or, am I becoming lazy?"

The Catholic Round Table of Science

Representatives of fifteen Catholic colleges and universities attended a meeting of the New York chapter of the Catholic Round Table of Science which was held in March at Fordham University. Addresses were made by Rev. Aloysius J. Hogan, S.J., President of Fordham University, Rev. J. Joseph Lynch, S.J., Head of Fordham's department of physics, Father F. P. LeBuffe, S.J., of New York, and Dr. Frank Thone of Science Service, Washington, D. C.

This meeting is of historical importance, as the *Catholic News* of New York points out, because it was the first meeting of the first, and so far the only, local chapter of the Catholic Round Table of Science that has ever been established. It directed attention to an important national group of Catholic scientists, and an organization of whose existence many persons are not aware.

The Catholic Round Table of Science is an informal and loose organization of nearly 600 Catholic scientists and other Catholics interested in scientific matters. Its membership is not restricted to instructors in colleges or even to science teachers in the secondary field. Any interested Catholic may join. The Round Table has no officers except a permanent secretary, the Very Reverend Anselm M. Keefe, O.Praem., Ph.D., rector of St. Norbert College, West DePere, Wisconsin. The meetings of the national group are held in connection with the annual convention of the American Association for the Advancement of Science, although the Round Table is not formally organized as a section of this great body of scientists. Such a division is unnecessary because science as science is neither Catholic nor non-Catholic. It is neutral as regards religious belief. Members of the Round Table are encouraged to work with scientists not of the faith, and to share the results of their researches with them as well as with those who are Catholics.

The Round Table was organized in 1928 at the suggestion of Dr. John M. Cooper of the Catholic University. Informal luncheons, followed by discussions of scientific matters, have been held yearly. Its purpose is to encourage productive scholarship in the natural sciences in Catholic colleges and universities, and to bring together Catholic scientists and scientific thinkers for mutual aid and encouragement.

The Very Reverend Secretary each year prints privately and distributes to the members a bulletin—The Tabloid Scientist—which forms a record of the annual meetings and furnishes a list of the members. Those who are interested should communicate with him.

Science Notes

In his study of the passage of sound through gases Dr. Vern O. Knudsen of the University of California has learned that oxygen is the gas which most effectively dampens sound. In pure oxygen, sounds of high pitch are lost in passing through comparatively short distances. In such an atmosphere women and children would seem to speak with deep voices because the high tones in their voices would be absorbed.

The walls and ceilings of public halls and theatres are often covered with cloth hangings or other sound absorbent material in order to prevent the echoing which results from the reflection of sounds; but Dr. Knudsen reports that the absorption of sounds of high frequency in a room is influenced more by the humidity and the temperature than it is by the walls and their covering.

•

Dr. George L. Clark of the University of Illinois has announced that by means of a special technique using polarized light and a powerful microscope he and his colleagues have at last been able to see, in the cytoplasm of plants, egg-shaped molecules of pure cellulose joined end-to-end in a chain-like formation.

Each molecule is one and one-half microns long. A molecular weight for cellulose of 500,000 is indicated. The giant size of the cellulose molecules is apparent when it is noted that each molecule is one-half million times as heavy as an atom of hydrogen.

Dr. Vilhjalmur Stefansson, the famous Arctic explorer, stated recently in an address before the Pennsylvania Historical Society that America was discovered by Irishmen long before Columbus made his famous voyage. Irishmen colonized Iceland and Greenland in the fifth and sixth centuries. Others who have studied the question agree with Dr. Stefansson.

•

When it was first isolated, the price of heavy water was exceedingly high, $80.00 a gram. By a new method of distillation Dr. D. S. Cryder of Pennsylvania State College has been able to obtain enough of the pound of heavy water that exists in every two and one-half tons of ordinary water, so that it can be sold for one-fourth the first cost. The Norwegians, however, are able to sell heavy water, made by an electrolytic process, for as little as $2.00 a gram.

•

The lowest temperature ever reached by man was recorded recently in the laboratories of Leyden University, the Netherlands, when a temperature of one five-thousandths of a degree above zero was reached.

Absolute zero is 273.15° below zero on the Centigrade scale. Professor W. J. DeHaas and his co-workers used a special magnetic method which employs salts cooled to an extremely low temperature by liquid helium and later placed in a magnetic field of varying intensities.

A Science Teacher Answers

Continued from Page Six

The recording of scientific data in the notebook is an important means of insuring the remembering of an experiment. When properly done, it aids logical thinking. I find the use of the blackboard in the laboratory very helpful. We are assembled in the laboratory for an experiment. Today we are to prepare hydrogen by the reaction between an acid and a metal, such as sulfuric acid and zinc. Then we will study the characteristics of this gas.

"Go to the board, John, and write what we tell you."

"How shall we state the object of this experiment, Harry? Do you agree with Harry's statement? Can anyone improve it?"

The object of the experiment is now written on the board.

"In our experiment we use this apparatus. Take out each piece as I name it, and place it on your desk."

The teacher lists the apparatus on the board.

"I shall show you how to assemble your apparatus. Have pencil and paper ready to note the special instructions I give you." A diagram is placed on the board. Directions are now given for the placing of the thistle tube, with the reasons therefor. The class is told how to test for airtightness. The technic of collecting gas is demonstrated, and the danger of explosion and of injury from shattered glass is explained.

You may think all this detail work is a waste of time. It would be for the student in April, but not for the beginner in September. The inexperienced pupil cannot follow printed directions accurately. The teacher's directions are often simpler and easier to understand than the ones found in the laboratory manual.

The experiment is finished. Before cleaning up, send another pupil to the board. Call upon individual members of the class to tell what each has observed and what each has learned by the experiment. Their several observations are placed under the correct captions. Let the pupils draw their own conclusions. After discussion these, too, are placed on the blackboard. Finally, the pupil records the experiment in his book. The student who will let another pupil think for him is soon found out by questioning him in the laboratory. When he is exposed as a "chiseler," he becomes ashamed of himself.

Perhaps you have been told, as I have been, that teaching science is very easy. "You have the materials to see and to handle." We admit that. But what about such scientific concepts as Avagadro's hypothesis that must be taught in the abstract?

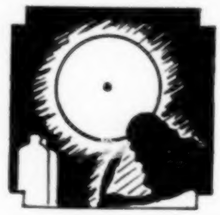
Her anxiety concerning the science equipment and her care of it will be the cause of the gaining of many "partial indulgences" for any science teacher. Her work is never done. Experiments and their controls must be set up, cultures made, collections of leaves and fruits obtained, and fish, frogs, snakes, turtles and paramecia cared for. How many science teachers are given free periods in which to prepare for their laboratory work? Are they not hampered by home-room groups, attendance, tardiness, office statistics and the other essentials necessary in the administration of the school?

Let me don the rose glasses again. What battles or what heroes of history can compare with our great scientists and their labors in the conquest of disease? What wonders of the unseen world are ours under the microscope? How close are we to the Great Designer and His laws! To know Him more ardently is the goal of the Catholic science teacher in her endeavor to make Him known and appreciated by His children.

Teaching science is not easy.

Would we exchange our arduous work for that of some other field?

Let another teacher answer.



In Future Numbers

The December number of The Science Counselor will direct attention to some of the recently published textbooks in high school science.

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Among the writers who will contribute articles to the December number or to future numbers are listed:

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REV. J. JOSEPH LYNCH, S.J., head of the Department of Physics, Fordham University.

●

ROBERT T. HANCE, head of the Department of Zoology, University of Pittsburgh.

●

DR. FRANK THONE, of Science Service, Washington, D. C.

●

GERALD C. McDONALD, Associate Professor of Chemistry, St. Francis College, Brooklyn, N. Y.

●

JOHN F. MATEJCZYK, Assistant Professor of Chemistry, Duquesne University.

●

GEORGE J. RALEIGH, Department of Botany, Cornell University.

●

T. C. MAY, Department of Geology, Catholic University.

WILLIAM R. TEETERS, Supervisor Physical and Biological Sciences, St. Louis Public Schools, St. Louis, Mo.

●

IVAN G. HOSACK, Perry High School, Pittsburgh, Pa.

●

RT. REV. GEORGE BARRY O'TOOLE, head of the Department of Philosophy, Duquesne University.

●

WILLIAM HELFRICH, Titusville High School, Titusville, Pa.

●

MAURICE AMES, Chairman of the Department of Physical Science, George Washington High School, New York City.

●

E. S. RUSSELL, Cambosco Scientific Co., Waverley, Mass.

●

MARY W. MULDOON, Principal of the Junior High School, Waverly, N. Y.

●

LOUIS E. WELTON, Assistant Principal and former head of the science department, John Hay High School, Cleveland, Ohio.

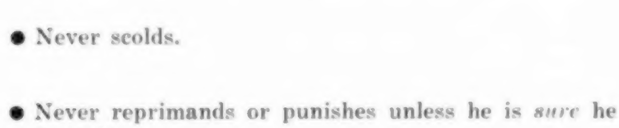
●

ANDREW KOZORA, Instructor in Physics, Duquesne University.

The Good Teacher:

- Begins the new year with a determination to teach better than ever before.
- Prays daily that he will not be sarcastic to his students. Sarcasm is often cowardly.
- Watches the *class*, not the student who is reciting. That student will take care of himself.
- For his blackboard demonstrations selects a slate that can be seen by *all* in the room. He always uses the same slate.
- Watches the lighting, temperature and ventilation of his classroom.
- Realizes that yawns, turning around, day dreaming, and frequent requests to leave the room are danger signals.
- Teaches caution in forming conclusions, and mental integrity in drawing only such conclusions as the facts justify.
- Studies his own idiosyncrasies and takes steps to remedy them.
- Avoids memory stunts.
- Never forgets to be courteous.
- Never threatens his pupils.
- Never scolds.
- Never reprimands or punishes unless he is *sure* he is right
- Avoids criticizing or reprimanding a pupil in the presence of his classmates.

Do You Do These Things?



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